

Departure from the Standard Model of Meson Decays and Cartan's Supersymmetry

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November 25, 2015

Abstract

The experimental decay branching ratios of mesons like $B_s \rightarrow \ell\bar{\ell}$ and $B_d \rightarrow \ell\bar{\ell}$ ($\ell = e$ or μ) do not agree completely with the standard model (SM).

Cartan's supersymmetry predicts relation of the coupling of vector particles x_μ, x'_μ , ($\mu = 1, 2, 3, 4$) to Dirac spinors of large components ψ, ϕ and small components $\mathcal{C}\psi, \mathcal{C}\phi$. In the decay of $B_d = \bar{b}d$, the Cabibbo-Kobayashi-Maskawa (CKM) model suggests that the contribution of t quark dominates, while in the decay of $B_s = \bar{b}s$, contribution of c quark in the intermediate state is expected to be large, since s and c quark belong to the same CKM sector. The relative strength of the t quark and c quark contribution in Cartan's supersymmetric model has more freedom than that of the SM. Together with the problem of enhancement of $B_d \rightarrow J/\Psi K_0$ in high Δt region, we can understand the problem of branching ratios of B decay into $e\bar{e}$ and $\mu\bar{\mu}$, if the Nature follows Cartan's supersymmetry.

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1 Introduction

Recently universality of lepton flavor in the decay of B mesons was questioned by the LHCb group[1] and conjectures based on the QCD with additional currents were given in [2, 3, 4, 5]. In [6], violation of the flavor symmetry due to admixture of c quark contribution to the t quark contribution was studied, and we want to extend the theory to the decay of B mesons.

Decay branching ratios of mesons to lepton pairs or a pion and lepton pairs are good testing ground of the standard model (SM). Comparison of experimental decay branching ratios of $B_{s,d} \rightarrow \ell\bar{\ell}$, $K \rightarrow \pi\ell\bar{\ell}$, $K^+ \rightarrow \pi^+\nu\bar{\nu}$ and $K_L \rightarrow \pi^0\nu\bar{\nu}$ with that of SM were discussed in [7, 8, 9, 10, 11, 13, 14, 15, 16, 18, 19].

In the SM the strength of transitions of a quark to different flavor states is defined by the Cabibbo-Kobayashi-Maskawa (CKM) matrices. For example, the branching ratio of $B_s \rightarrow \ell\bar{\ell}$ depends on the probability of the coupling of an s quark + emitted vector particle to a \bar{b} quark + absorbing vector particle which depends on $|V_{cb}|^2 \times |V_{tb}^*V_{ts}/V_{cb}|^2$, and the branching ratio of B_d depends on the probability of the coupling of a d quark + emitted vector particle to a \bar{b} quark + absorbing vector particle which depends on $|V_{tb}^*V_{td}|^2$.

Comparisons of theoretical meson decay matrix elements and experiments were done in various processes, and recently a summary of lattice simulation results was given by the FLAG group [20]. But the lattice cannot give consistent branching ratios of B_d and B_s mesons together.

Violation of CP symmetry or time reversal symmetry in the decay of B mesons was studied in the difference of

$$\begin{aligned} B^0 &\rightarrow \ell^-\nu_\ell + X, J/\psi\bar{K}_L^0, \quad \text{v.s.} \quad \bar{B}^0 \rightarrow \ell^+\nu_\ell + X, J/\psi K_L^0 \\ B_s &\rightarrow \ell^-\nu_\ell + X, J/\psi\bar{K}_L^0, \quad \text{v.s.} \quad \bar{B}_s \rightarrow \ell^+\nu_\ell + X, J/\psi K_L^0, \end{aligned}$$

and CP violation was observed in B^0 decay but not in B_s decay. Qualitative differences of $B^0 \rightarrow \ell\bar{\ell}$ and $B_s \rightarrow \ell\bar{\ell}$ were also observed.

Since complete non leading order corrections in $b \rightarrow s\gamma$ and $b \rightarrow sg$ transitions are not

available[7], we apply Cartan's octonion theory to solve the problem of branching ratios of B mesons.

In [21] we studied Cartan's supersymmetry[22] and studied coupling of fermions and vector particles which transform under groups $G_{23}, G_{12}, G_{13}, G_{123}$ and G_{132} .

Cartan considered only electromagnetic interactions, but extension to weak interaction is possible[6]. We applied the Cartan's supersymmetric model to $B^0 \rightarrow K_L J/\Psi$ and found modification of coupling occurs in a certain channel as compared to the SM[24, 25].

In the section 2, we summarize the status of meson decay branching ratios, and in the section 3 we explain the method of analyzing the meson decay using Cartan's supersymmetry. Discussion and conclusion are given in section 4.

2 Deviation of B meson decay branching ratios from the Standard Model

When one uses results of K meson decay to $\pi\ell\bar{\ell}$ or $\ell\bar{\ell}$ states to analyses of B_d meson or B_s decay to $K\ell\bar{\ell}$ or $\ell\bar{\ell}$ states, one encounters problems.

2.1 $B_d \rightarrow K\ell\bar{\ell}$ and $B_s \rightarrow K\ell\bar{\ell}$

From the universality of leptons, the strength of $B^+ \rightarrow K^+ \mu \bar{\mu}$ and that of $B^+ \rightarrow K^+ e \bar{e}$ are expected to be the same, but experimentally

$$\frac{Br(B^+ \rightarrow K^+ \mu \bar{\mu})}{Br(B^+ \rightarrow K^+ e \bar{e})} = 0.745_{-0.074}^{+0.090}(stat) \pm 0.036(syst).$$

is observed by the LHCb group[1].

The inclusive $b \rightarrow s\ell\bar{\ell}$ decay modes were studied by several authors and an extension of Randall and Sundrum model[26, 27] to $B \rightarrow K\ell\bar{\ell}$ transition was tried in [28, 29].

In the custodially protected Randall Sundrum model (RS_c), additional $U(1)$ current in dark sector was proposed to solve $b \rightarrow s$ anomalies [4, 5]. We do not assume this current,

but adopt the vertex with $1 - \gamma_5$ factor for the weak interaction, and consider two triangle diagrams in the coupling.



Figure 1: The vertex of $B^+ \rightarrow K^+ \ell \bar{\ell}$ (left) and $B^0 \rightarrow K^0 \ell \bar{\ell}$ (right).

The $b \rightarrow s \ell \bar{\ell}$ vertex requires renormalization of penguin diagrams.



Figure 2: The penguin diagram of $B^+ \rightarrow K^0 \ell \bar{\ell}$ (left) and $B^0 \rightarrow K^0 \ell \bar{\ell}$ (right).

The lepton pairs can be $e \bar{e}$ which transform mainly to γ or $\mu \bar{\mu}$ which transform mainly to Z . The CKM model implies higher order effect of coupling of γ to b quark is dominated by the loop of t quarks, but difficulty of the CKM model to explain the decay of $B \rightarrow K + X$ transitions implies contamination of the loop of $b - c - s$ quarks in addition to $b - t - s$ quarks, since s and c quark belong to the same CKM sector.



Figure 3: The Feynman diagrams including two loops of $B^+ \rightarrow K^+ e \bar{e}$ (left), and $B^+ \rightarrow K^+ \mu \bar{\mu}$ (right).

2.2 $B_s \rightarrow \ell\bar{\ell}$ and $B_d \rightarrow \ell\bar{\ell}$

The decay of $B_{s,d} \rightarrow \ell^+\ell^-$ ($\ell = e, \mu$ and τ) in the standard model contains two γ_5 verices and the intermediate state is Z or H , as shown in Fig.4.

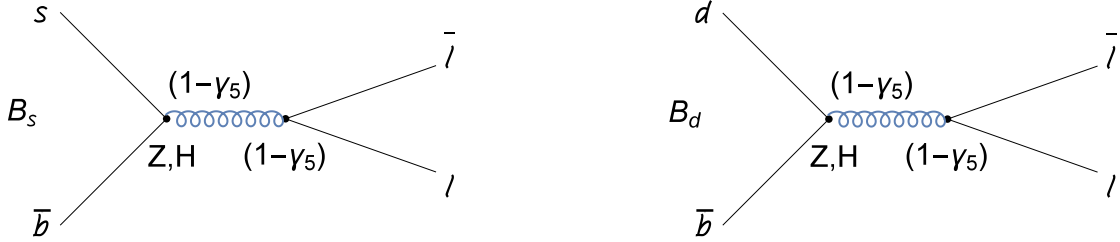


Figure 4: The electro-weak interaction quark diagrams of $B_s \rightarrow \ell\bar{\ell}$ (left), and $B_d \rightarrow \ell\bar{\ell}$ (right).

They defined the Lagrangian for $B_q \rightarrow \ell\bar{\ell}$ as

$$\mathcal{L}_{weak} = N C_A(\mu_b)(\bar{b}\gamma_a\gamma_5 q)(\bar{\ell}\gamma^a\gamma_5\ell) + O(\alpha_{em})$$

and averaged time-integrated branching ratios proportional to

$$\begin{aligned} \bar{B}_{s\ell} &\propto |N|^2 |C_A(\mu_b)|^2 \tau_H^s \\ &\propto f_{B_s}^2 |V_{cb}|^2 (|V_{tb}^* V_{ts}/V_{cb}|)^2 \tau_H^s, \end{aligned} \quad (1)$$

where $\tau_H^s = 1/\Gamma_H^s$ is the lifetime of the heavier mass eigenstate of B [17], V_{tb} , V_{ts} and V_{cb} are CKM matrix elements, was calculated for $B_s \rightarrow \mu^+\mu^-$, and

$$\bar{B}_{d\ell} \propto f_{B_d}^2 |V_{tb}^* V_{td}|^2 \tau_d^{av}$$

where $\tau_d^{av} = 2/(\Gamma_H^d + \Gamma_L^d)$ is the average of the lifetime of the lighter mass and heavier mass eigenstate of B , V_{tb} and V_{td} are CKM matrix elements, was calculated for $B_d \rightarrow \mu^+\mu^-$.

In the SM, the decay branching ratio of B_d and B_s yields direct information on V_{bt} , V_{st} and V_{bc} , but uncertainty in the CKM matrix element V_{bc} was not seriously taken into account.

Blanke et al.[18] presented the review of $K_L \rightarrow \ell\bar{\ell}$, $B \rightarrow K\ell\bar{\ell}$ and $B \rightarrow \ell\bar{\ell}$. According to their work experimental world average branching ratio

$$\bar{B}(B_s \rightarrow \mu^-\mu^+) = (2.9 \pm 0.7) \times 10^{-9}$$

is slightly smaller than the theoretical value $(3.65 \pm 0.23) \times 10^{-9}$ [14].

In the case of $B_d \rightarrow \mu^- \mu^+$, there are larger experimental uncertainty[15], however the experimental world average branching ratio

$$\bar{B}(B_d \rightarrow \mu^- \mu^+) = (3.6^{+1.6}_{-1.4}) \times 10^{-10}$$

is much larger than the theoretical value $(1.06 \pm 0.09) \times 10^{-10}$ [14].

A two loop calculation of branching ratio including the diagram of the penguin diagram was done by [10] for the $K_L \rightarrow \mu^+ \mu^-$. If a neutrino is a Majorana neutrino and ν and $\bar{\nu}$ are indistinguishable, one can consider the decay through the box diagram[11, 10]. But there is no clear experimental results that suggests $\nu|_{Majorana} = \bar{\nu}|_{Majorana}$. If neutrino is massive, it is difficult to identify a neutrino and an antineutrino.

We expect the decay of $K_L \rightarrow \mu^+ \mu^-$ and $B \rightarrow \mu^+ \mu^-$ are not dominated by Fig.4, we study c quark contribution is important. In the case of $K_L \rightarrow \mu^+ \mu^-$ we consider the $q-\bar{q}-W$ triangle diagram with a penguin loop studied as [10] and the $W^+ - W^- - q$ triangle diagram. We do not assume that the penguin loop is given by a gluon but by a Z boson. A gluon has unphysical components and it can be replaced by a gauge potential and ghost fields[23].

Since the s quark and the c quark are in the same CKM sector, we expect in the $q-\bar{q}-W$ triangle, some contribution of $c\bar{c}$ quark to the usual $t\bar{t}$ quark contribution. Since a c quark is heavier than a s quark, the contribution is less important than $B_d \rightarrow \ell\bar{\ell}$ or $B_s \rightarrow \ell\bar{\ell}$.

In [24] we analyzed $B_d \rightarrow K_L J/\Psi$ decay process using Cartan's supersymmetry and compared the results with SM using CKM matrix elements. We perform the similar analysis for K meson and B meson decays into lepton pairs.

In the previous analysis of $B_d \rightarrow K_L J/\Psi$, a vector particle was emitted from a quark or an anti-quark in a meson and transformed to J/Ψ , but in the present case we consider processes in which a vector particle transform to $\ell\bar{\ell}$.

The coupling of the vector particle which was the source of J/Ψ was pseudo scalar type $t\bar{\psi}\gamma_\mu\gamma_5\psi$.

The agreement of branching ratios of meson decays in theoretical models and the SM is not sufficient. One could imagine new physics, in which heavy mesons X^+X^0 instead of W^+Z contribute[15]. However, it may be appropriate to study supersymmetry of quarks or leptons and vector particles more in detail.

3 Cartan's supersymmetry and meson decays

In the SM, the simplest amplitudes of $B \rightarrow \ell\bar{\ell}$ contains two γ_5 vertices, since electromagnetic decay is impossible. In the Cartan's supersymmetric model, W^+, W^- and Z bosons are replaced by vector particles $x_1, x_2, x_3, x_4, x'_1, x'_2, x'_3$ and x'_4 , and quarks and leptons are replaced by Dirac spinors $(\psi, \mathcal{C}\psi)$ and $(\phi, \mathcal{C}\phi)$. Incorporation of ϕ quarks allows decay amplitudes containing only one γ_5 vertex from a part of ${}^t\bar{\phi}\gamma_\mu(1 - \gamma_5)\psi$.

3.1 $K_L \rightarrow \ell\bar{\ell}$ and $B_{s,d} \rightarrow \ell\bar{\ell}$

Simple diagrams of $K_L \rightarrow \ell\bar{\ell}$ containing the vertex corresponding to that of W^+W^-Z are shown in Fig.5.

In our diagram of $K_L \rightarrow \ell\bar{\ell}$ shown in the left side of Fig.5, the symbol x'_3 corresponds to Z boson with the momentum direction x'_3 , the symbol x_4 corresponds to W^+ with the momentum direction x_4 , and the symbol x'_4 corresponds to W^- with the momentum direction x'_4 . The vector particle x_4 couple with ξ_{12} of $\mathcal{C}\phi$ and create ξ_{34} of anti-quark ϕ and the vector particle x'_4 is emitted from ξ_3 of ψ and create the ξ_{12} .

In order to make coupling of a quark to W^+ and W^- bosons, it is necessary to include a γ_5 vertex which couples ϕ and $\mathcal{C}\psi$ or ψ and $\mathcal{C}\phi$. A quark emitted as $\mathcal{C}\phi = \xi_{12}$ can be absorbed as $\mathcal{C}\psi = \xi_{124}$ at the γ_5 vertex.

We extend the Cartan's supersymmetric model to allow a spinor

$$\tilde{\psi} = \xi_1 \mathbf{i} + \xi_2 \mathbf{j} + \xi_3 \mathbf{k}$$

and an antispinor

$$\tilde{\phi} = \xi_{14}\mathbf{i} + \xi_{24}\mathbf{j} + \xi_{34}\mathbf{k}$$

annihilate to a scalar particle $Z = x'_4$. Including the vertex $\xi_i \xi_{i4} Z$ vertices, we can consider penguin diagrams of [10], which are shown in the right hand side of Fig.5. In the diagrams there are triangle diagrams of $q(t/c) - \bar{q}(\bar{t}/\bar{c}) - W$ boson (x'_i) and a loop of Z boson (x'_4/x_4). Due to this loop, coupling of a quark to the Z boson(x'_4) becomes possible, without including a γ_5 vertex. They appear as a correction from weak interactions.

In our model, we allow transformation of x_i to $x_{i'}$ during propagations, and since K_L consists of $\bar{s}d$, and \bar{s} quark and \bar{c} quark are in the same sector of CKM model, the $q(\bar{q})$ on the triangle is assumed to be $t/c(\bar{t}/\bar{c})$. In other words, we take into account the correction to the t quark loop dominance in the SM.

In the calculation of the right hand side of Fig.5, we fix the d quark and the \bar{s} quark, both large components and exchange a vector particle between d and \bar{s} . In the first diagram, the d quark ξ_3 becomes after emitting a vector particle $x_{1'}$ becomes a \bar{t} quark or a \bar{c} quark ξ_{24} , and after emitting a particle $x_{4'}$ corresponding to a Z boson becomes a quark ξ_2 and after emitting x'_4 , becomes an anti-quark ξ_{31} . The \bar{s} quark ξ_{34} emits a x_4 and becomes a quark ξ_{124} . The $\mathcal{C}\psi\mathcal{C}\phi$ state of $\xi_{124}\xi_{31}$ has an overlap with the vector particle x_1 and absorbs the previously emitted x'_1 . The Z boson x'_4 becomes an $\ell\bar{\ell}$ pair. By admitting an overlap of $x_1 x'_4$ and $x'_1 x_4$ state, $d\bar{s} \rightarrow \ell\bar{\ell}$ transition becomes possible. The contribution of c or \bar{c} quark is expected to be not so important since $m_c > m_s$ and virtual transition to t whose mass $m_t > m_H$ is not expected to be affected.

In the case of B_d we replace the \bar{s} quark to \bar{b} quark. In the case of B_s we replace the d quark in B_d to an s quark and t/\bar{t} quark to c/\bar{c} quark, since a c quark is in the same CKM sector as an s quark, and $m_c < m_b$, we need to incorporate the effect of a c quark.

The quark diagrams of $B_d \rightarrow \ell\bar{\ell}$ processes are given in Fig.6 and that of $B_s \rightarrow \ell\bar{\ell}$ processes are given in Fig.7.

The qualitative difference of experimental and theoretical branching ratios of $\bar{B}_{s\mu}$ and

$\bar{B}_{d\mu}$ may originate from the difference of quarks propagating on the triangle of two loop diagrams between s and \bar{b} and d and \bar{b} . In the case of B_s , since the s quark belongs to the same sector as the c quark, after emitting a vector particle x'_i , it can be transformed to an antiquark \bar{c} and emits a vector particle x'_4 which changes to $\ell\bar{\ell}$, returns to a quark c which emits a vector particle x'_4 . The c quark absorbs the emitted vector particles x'_i and x'_4 and transforms to a \bar{b} quark.

In the case of B_d , the d quark is transformed to \bar{t} quark after emitting a vector particle x'_i as shown in the right-hand part of diagrams. The product $V_{ud}V_{ub}^*$ of CKM matrices gives the strength, and the \bar{t} quark emits an x'_4 and transforms to a \bar{b} quark after absorbing the emitted x'_4 on the γ_5 vertex.

The relative intensity of the left-hand side diagrams and the right-hand side diagrams of Figs.5, 6, and Fig.7 are not evident. We expect the left-hand side dominates, and reflects the CKM matrix elements, however in $B_s \rightarrow \ell\bar{\ell}$ the right-hand side diagram containing a c quark propagation gives a slight suppression to the left-hand side dominant term, and in $B_d \rightarrow \ell\bar{\ell}$ the right-hand side diagram containing a t quark propagation is expected to give an enhancement to the dominant term.

4 Discussion and conclusion

Description of Dirac fermions is not unique. The sub algebra $\mathbf{R}_{3,1}^+$ with a basis

$$\{\mathbf{1}, \mathbf{e}_1\mathbf{e}_2, \mathbf{e}_1\mathbf{e}_3, \mathbf{e}_2\mathbf{e}_3, \mathbf{e}_1\mathbf{e}_4, \mathbf{e}_2\mathbf{e}_4, \mathbf{e}_3\mathbf{e}_4, \mathbf{e}_1\mathbf{e}_2\mathbf{e}_3\mathbf{e}_4\}$$

where \mathbf{e}_i satisfy $\mathbf{e}_1^2 = \mathbf{e}_2^2 = \mathbf{e}_3^2 = \mathbf{1}, \mathbf{e}_4^2 = -\mathbf{1}$ is equivalent to Pauli algebra, defined by $\mathbf{e}_1\mathbf{e}_4 = \sigma_1, \mathbf{e}_2\mathbf{e}_4 = \sigma_2, \mathbf{e}_3\mathbf{e}_4 = \sigma_3$ and

$$\mathbf{e}_1\mathbf{e}_2\mathbf{e}_3\mathbf{e}_4 = \sigma_1\sigma_2\sigma_3 = \mathbf{i}.$$

CKM matrices were derived based on this algebra[31]

In the n dimensional linear space V over a field \mathbf{F} and exterior algebra $\wedge V$, octonion appears by defining $\mathbf{e}_1\mathbf{e}_2\mathbf{e}_3 = \boldsymbol{\ell}$, and choosing

$$\{\mathbf{1}, \mathbf{e}_1, \mathbf{e}_2, \mathbf{e}_3, -\mathbf{e}_3\boldsymbol{\ell}, -\mathbf{e}_2\boldsymbol{\ell}, -\mathbf{e}_1\boldsymbol{\ell}, \boldsymbol{\ell}\}$$

as the basis of the field[32, 33]. The commutation relations of \mathbf{e}_i are not same as those of Cartan's ξ_i .

The rules of multiplication of \mathbf{e}_i follow Clifford algebra[34]. Lounesto[35] pointed out that a product of Clifford numbers \mathbf{x} and \mathbf{y} in n dimensional linear space V over a field \mathbf{F} defined by Chevalley[36] is

$$\mathbf{xy} = \mathbf{x} \wedge \mathbf{y} + \mathbf{x} \lrcorner \mathbf{y} = \mathbf{x} \wedge \mathbf{y} + B(\mathbf{x}, \mathbf{y})$$

where $\mathbf{x} \wedge \mathbf{y}$ is the antisymmetric product, and $\mathbf{x} \lrcorner \mathbf{y}$ is the contraction which depends on \mathbf{F} .

When $\mathbf{F} = \{0, 1\}$ and an exterior algebra $\wedge V$ has the basis $\{1, \mathbf{e}_1, \mathbf{e}_2, \mathbf{e}_1 \wedge \mathbf{e}_2\}$, there are two bilinear forms $B_1(\mathbf{x}, \mathbf{y}) = x_1y_2$ and $B_2(\mathbf{x}, \mathbf{y}) = x_2y_1$ which do not have a canonical multiplication table.

The time(space) component of $\psi = \xi_4(\xi_i)$ and that of $\phi = \xi_0(\xi_{i4})$ satisfy the commutation relation

$$\frac{1}{2}(\xi_0\xi_4 - \xi_4\xi_0) = 1, \quad \frac{1}{2}(\xi_{i4}\xi_i - \xi_i\xi_{i4}) = 1 \quad (i = 1, 2, 3)$$

Similarly, those of $\mathcal{C}\psi = \xi_{123}(\xi_{ij4})$ and $\mathcal{C}\phi = \xi_{ij3}(\xi_{ij})$ satisfy the commutation relation

$$\frac{1}{2}(\xi_{1234}\xi_{123} - \xi_{123}\xi_{1234}) = 1, \quad \frac{1}{2}(\xi_{ij}\xi_{ij4} - \xi_{ij4}\xi_{ij}) = 1 \quad (ij = 12, 23, 31).$$

Due to this difference of commutation relation of the space components and time components of ψ and ϕ , we can define unique octonion in \mathbf{R}^8 space.

We applied Cartan's supersymmetry to analyze the decay branching ratios of K and B mesons to $\pi\ell\bar{\ell}$ and $\ell\bar{\ell}$. In the $B_{s,d} \rightarrow \mu^+\mu^-$ process, we assigned vector particles x_i to Z boson of polarization x_i and by allowing transition of $\mathcal{C}\phi$ and $\mathcal{C}\psi$ during the propagation of $b \rightarrow t \rightarrow \bar{s}$, we could make $B_{s,d}$ composed of large components ψ or ϕ .

The suppression of the $B_s \rightarrow \mu^+ \mu^-$ can be explained, if one takes into account that the c quark and s quark are in the same sector, and correction to the CKM mechanism is large in $B_s \rightarrow \mu^+ \mu^-$ than in $B_d \rightarrow \mu^+ \mu^-$. When s or c quarks are not present in the meson system, the vertex of vector particles $x_4 - x_4' - x_j' (j = 1, 2, 3)$ and the triangular loop of top quarks and one vector particle $t - \bar{t} - x_j'$ defines the decay branching ratios. When s or c quarks are in the meson, the loop of $c - \bar{c} - x_j'$ modifies the $t - \bar{t} - x_j'$ contribution.

In the case of $B_d \rightarrow \mu^+ \mu^-$, since d quark is not in the sector of c , only the loop of $t - \bar{t} - x_j'$ contribute, and if it adds the contribution of the one loop of $x_4 - x_4' - x_j' (j = 1, 2, 3)$, we can explain the enhancement of $B_d \rightarrow \mu^+ \mu^-$.

In the processes of $B_s \rightarrow \mu^+ \mu^-$ via exchange of Majorana neutrino[15], one allows a transition from ν to $\bar{\nu}$. In our model, $|e^-, \nu_e)_L, |\mu^-, \nu_\mu)_L, |\tau^-, \nu_\tau)_L$ and their charge conjugates make sectors, and a neutrino in the sector of $|\mu^-, \nu_\mu)_L$ can transform to $|\mu^+, \bar{\nu}_\mu)^*$ or $|\mu^+, \bar{\nu}_\mu)^{**}$ in the notation of [6], which can be interpreted as $\bar{\nu}_\mu$ in different triality sectors, which would not be detected by vector particles or leptons in the sector of the initial $|\mu^-, \nu_\mu)_L$, since for detection of a particle $a_i^{k(j)}$ in the sector k , corresponding necessary condition N_j also need to be transferred [30] from different sectors, and we may be allowed to ignore the $\nu \rightarrow \bar{\nu}$ transition.

If our electromagnetic detector can detect electromagnetic field transformed by G_{23} but cannot detect electromagnetic field transformed by other four transformations, and there are six lepton sectors

$$|e, \nu_e)^*, |\mu, \nu_\mu)^*, |\tau, \nu_\tau)^*, |e, \nu_e)^{**}, |\mu, \nu_\mu)^{**}, |\tau, \nu_\tau)^{**}$$

which cannot be detected by our detectors, the presence of dark matter can be explained.

We observed that starting from the meson wave function given by the large component of a quark and the large component of an anti-quark, qualitative features of the strength of the decay branching ratios can be obtained from Cartan's supersymmetry.

Cartan's octonion satisfies a triality automorphism that is supersymmetric, which octonions of [32, 33] don't satisfy. In our system of fermions and vector fields with interaction

${}^t\phi C(1 - \gamma_5)X\psi$, the operator γ_5 yields coupling between a large component of a quark and a large component of an antiquark which enhances certain B meson decay processes. It makes the branching ratio of B meson decays different from the CKM model.

If in the universe there are worlds which are transformed by G_{ij} and G_{ijk} , and our electromagnetic detector can detect the world transformed by G_{12}, G_{13}, G_{123} and G_{132} , and the uncertainty principle applies not only in our world but also whole universe, we can understand the presence of dark matter.

Departure from the standard model of $B_s \rightarrow \mu\bar{\mu}$ and $B_d \rightarrow \mu\bar{\mu}$ is due to the large correction from the c quark in the decay of B_s meson. We ignored $K \rightarrow \pi\nu\bar{\nu}$ and $B \rightarrow D\ell\bar{\nu}$ etc, whose information will serve for establishing the model of B mesons based on Cartan's supersymmetry.

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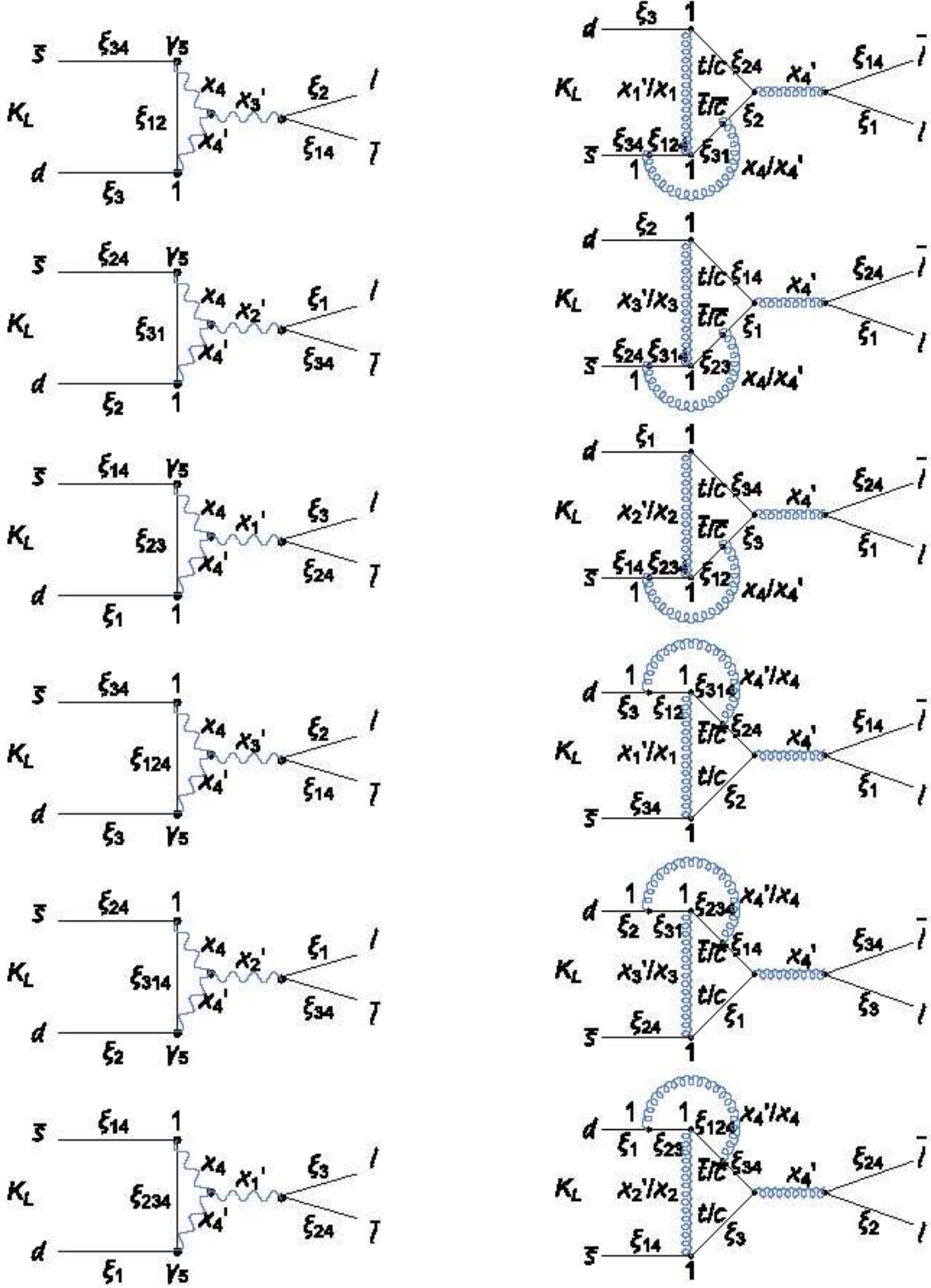


Figure 5: $K_L \rightarrow \ell \bar{\ell}$ quark diagrams containing $x_4 x_4' x_k'$ ($k = 1, 2, 3$) vertices with different γ_5 positions (left), and $q - \bar{q} - W$ triangle diagrams with different penguin loop positions (right).

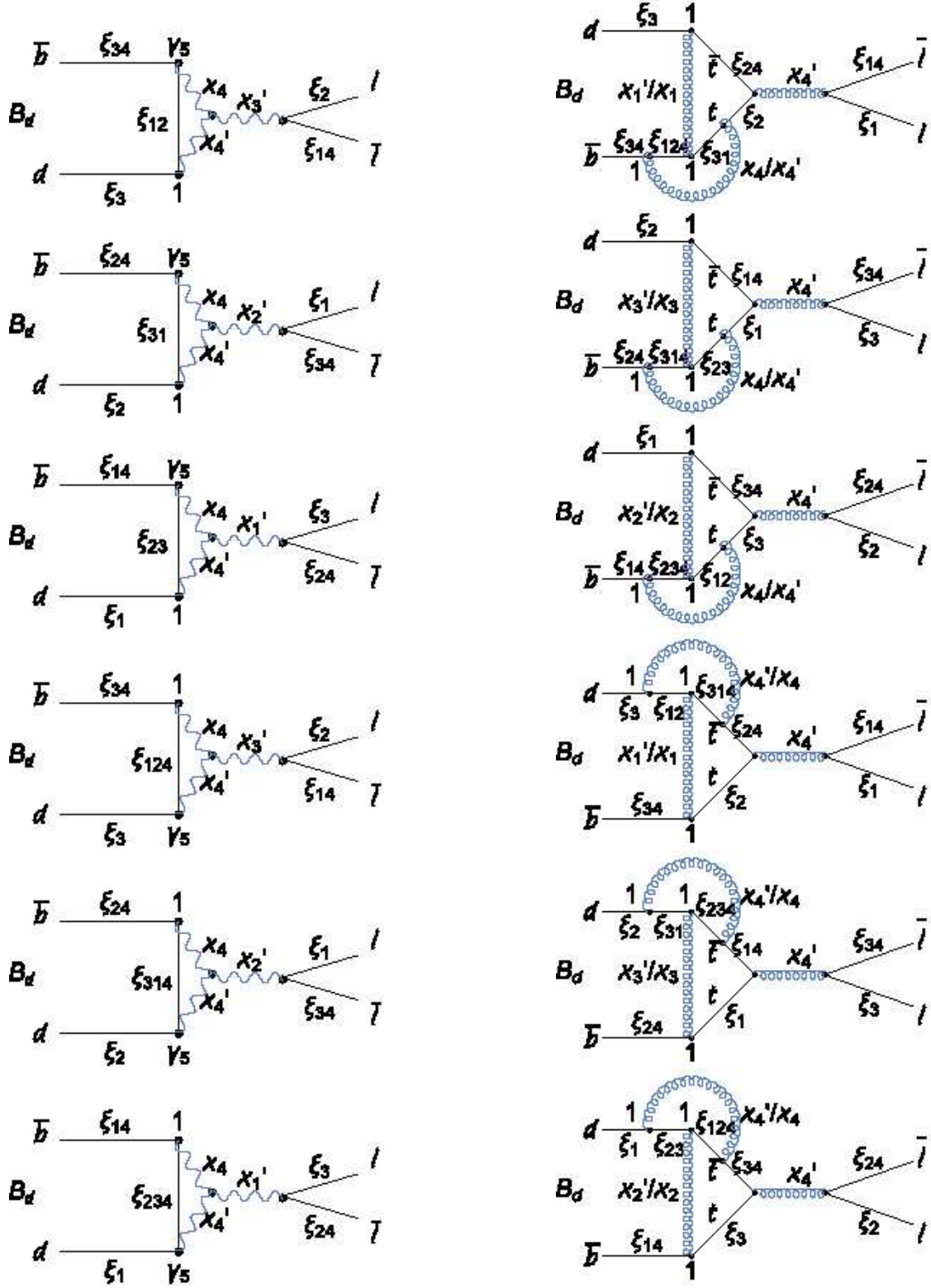


Figure 6: $B_d \rightarrow \ell \bar{\ell}$ quark diagrams containing $x_4 x_4' x_k'$ ($k = 1, 2, 3$) vertices with different γ_5 positions (left), and $q - \bar{q} - W$ triangle diagrams with different penguin loop positions (right).

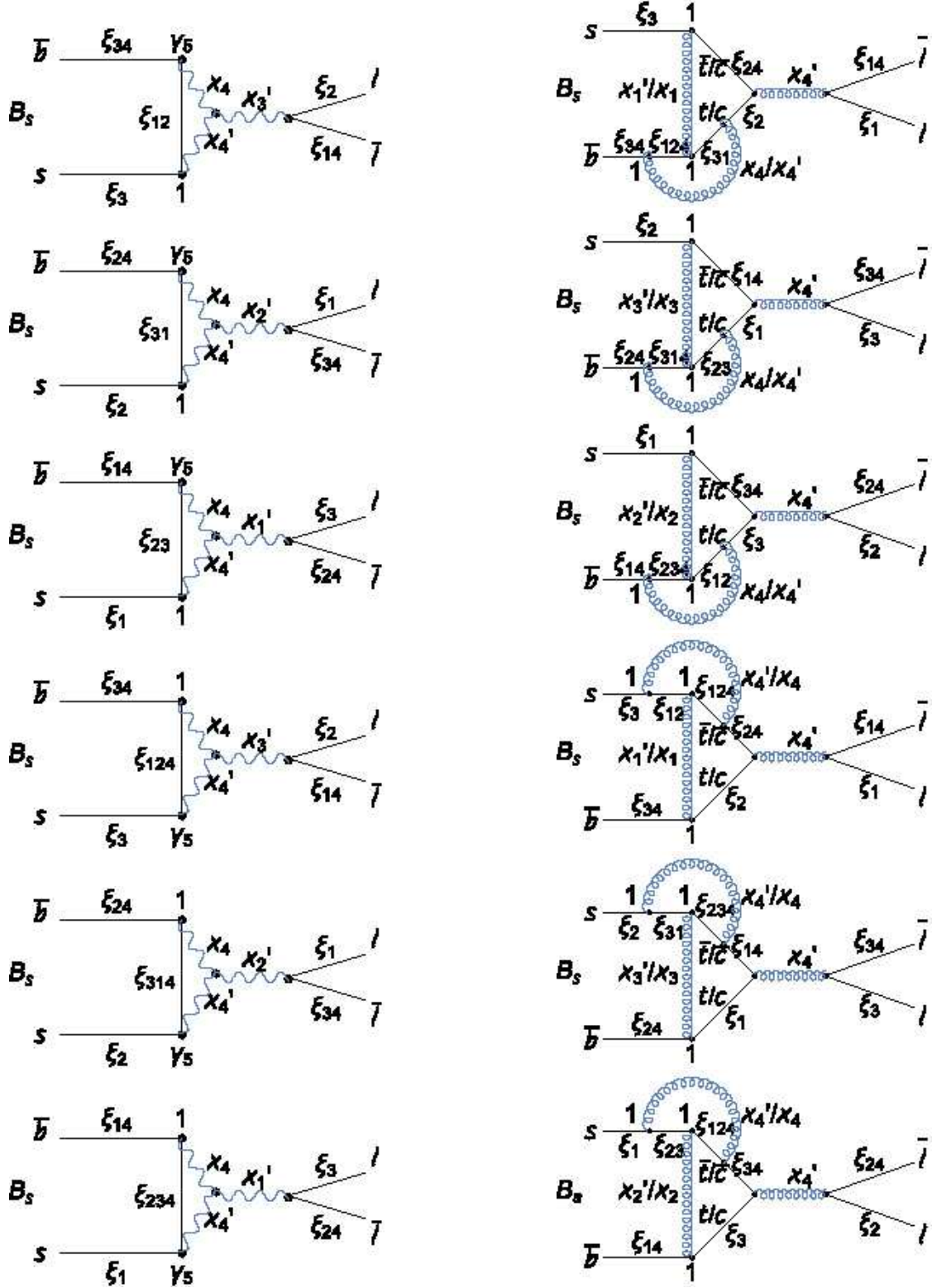


Figure 7: $B_s \rightarrow \ell \bar{\ell}$ quark diagrams containing $x_4 x_4' x_k'$ ($k = 1, 2, 3$) vertices with different γ_5 positions (left), and $q - \bar{q} - W$ triangle diagrams with different penguin loop positions (right).